# IDS 2010 Orbit Comparison Campaign: Results

*Doug Chinn, Frank Lemoine*

*IDS Analysis Working Group Meeting*

*Prague, Czech Republic*

*May 31, 2012*

# Objectives

- Intercompare DORIS AC orbits for 2010 for all existing satellites.

- Use, where available, independent combination orbits (slr+doris, slr +doris+gps). (An *alternate approach is to do a combination orbit – via a least squares fit – and assess the differences wrt. that combination ie like the IGS; Another possibility would be to take the DORIS-only orbits – where available and pass SLR data through them. This might be considered later*).

- Assess overall level of agreement.

- Identify where we can make improvements. New orbits or time series can be tested now relatively easily (for 2010 at least).

- Comparisons were complicated because of the many different time systems of the different orbits (GPS, TAI, UTC). All the orbits had to be interpolated to a common reference. There were additional complications adapting software we used for Jason2 orbit comparisons. (*D. Chinn persevered to make it all work*).

# 2010 Orbit Series

| Analysis Center | Series Name | Satellites (XXX) |
|---|---|---|
| CNES | ssaXXX01.byyDOY.eyyDOY.D_S.sp3.001 (slr+dor) | cs2, env |
| | XXX.yymmdd.cnes_ldg_gdrc (slr+dor+gps) | ja2 |
| | ssaXXX01.byyDOY.eyyDOY.D__.sp3.001 | sp4, sp5 |
| ESA | esawd06.yymmdd.XXX.sp3 | cs2,env,ja2,sp4,sp5 |
| GAU | XXX/orbfil_yymmdd.dat | cs2,env,ja2,sp4,sp5 |
| GOP | GOP_XXX_yymmdd_yymmdd_V33.sp3 | cs2,en1,ja2,sp4,sp5 |
| GSC | rv.XXyymmdd (*gscwd12 processing*) | c2,en,j2,s4,s5 |
| IGN | IGN_XXX_yymmdd-yymmdd_V1.sp3 | CR2,EN1,JA2,SP4,SP5 |
| INA | INA_XXX_yymmdd_yymmdd_V01.sp3 | CR2,ENV,JA2,SP4,SP5 |
| JPL | XXX.yymmdd.jpl_gpsr_rlse11a (gps-only) | ja2 |
| LCA | lcaXXX01.byyDOY.eyyDOY.D_S.sp3.001 (slr+dor) | cs2,en2,ja2 |
| | lcaXXX01.byyDOY.eyyDOY.D__.sp3.001 | sp4,sp5 |
| | lcaXXX01.byyDOY.eyyDOY.sp3.001 | en2,ja2,sp4,sp5 |

# 2010 Doris arcs

| AC | Time System | Arc (Days) | C2 | En | J2 | S4 | S5 |
|---|---|---|---|---|---|---|---|
| CNES | TAI-00 sec | 7 | May-Dec (+slr) | May-Dec (+slr) | | | |
| | TAI-00 sec | 10 | | | all (+slr +gps) | All | all |
| ESA | UTC-15 sec | 1 | May-Dec | all | all | all | all |
| GAU | UTC-00 sec | 7 | Jun-Dec | all | all | all | all |
| GOP | UTC-00 sec | 1 | May-Dec | all | all | all | all |
| GSC | UTC-00 sec | 7 | Jun-Dec | all | all | all | all |
| IGN | UTC-15 sec | 1 | May-Dec | all | all | all | all |
| INA | UTC-15 sec | 1 | May-Dec | all | all | all | all |
| LCA | TAI-00 sec | 3.5 | | Jan-Sep | Jan-Sep | Jan-Oct | Jan-Oct |
| | TAI-00 sec | 3.5 | Jun-Oct (+slr) | Oct (+slr) | Oct (+slr) | | |

# RMS Radial diffs wrt CNES (cm)

| C2 | | En | | J2 | | S4 | | S5 | |
|---|---|---|---|---|---|---|---|---|---|
| GAU | 0.95 | LCA | 0.70 | JPL | 1.00 | GSC | 0.80 | GSC | 0.72 |
| GSC | 1.01 | GSC | 0.77 | GSC | 1.13 | LCA | 0.87 | LCA | 0.82 |
| ESA | 1.10 | GAU | 0.84 | GAU | 1.15 | GAU | 0.96 | GAU | 0.85 |
| LCA | 1.24 | ESA | 1.03 | ESA | 1.28 | ESA | 1.34 | ESA | 1.27 |
| INA | 1.41 | INA | 1.12 | INA | 1.44 | INA | 1.46 | INA | 1.27 |
| IGN | 1.60 | GOP | 1.33 | GOP | 1.56 | GOP | 1.66 | GOP | 1.41 |
| GOP | 1.64 | IGN | 1.40 | LCA | 1.66 | IGN | 1.83 | IGN | 1.68 |
| | | | | IGN | 1.82 | | | | |

# Total RSS diffs wrt CNES (cm)

| C2 | | En | | J2 | | S4 | | S5 | |
|---|---|---|---|---|---|---|---|---|---|
| GAU | 4.58 | LCA | 3.41 | JPL | 3.21 | GSC | 3.72 | GSC | 3.37 |
| ESA | 4.61 | GSC | 3.44 | GSC | 4.56 | GAU | 4.12 | LCA | 3.64 |
| GSC | 4.71 | GAU | 3.59 | GAU | 4.59 | LCA | 4.94 | GAU | 3.66 |
| LCA | 4.88 | ESA | 4.16 | ESA | 4.95 | ESA | 5.51 | ESA | 4.72 |
| INA | 5.52 | INA | 4.43 | LCA | 6.68 | INA | 6.14 | INA | 5.18 |
| IGN | 5.95 | IGN | 5.52 | INA | 6.86 | IGN | 7.41 | IGN | 7.16 |
| GOP | 7.12 | GOP | 6.00 | GOP | 7.01 | GOP | 8.46 | GOP | 7.54 |
| | | | | IGN | 8.01 | | | | |

# Mean radial diff wrt CNES (cm)

| C2 | | En | | J2 | | S4 | | S5 | |
|---|---|---|---|---|---|---|---|---|---|
| ESA | -0.06 | GAU | -0.25 | LCA | -0.11 | ESA | -0.42 | ESA | -0.33 |
| GSC | -0.03 | ESA | -0.05 | IGN | -0.03 | GAU | -0.39 | LCA | -0.33 |
| LCA | -0.02 | LCA | 0.05 | JPL | 0.00 | GSC | -0.27 | IGN | -0.27 |
| GAU | -0.01 | GSC | 0.06 | ESA | 0.03 | IGN | -0.15 | GSC | -0.25 |
| GOP | 0.40 | IGN | 0.22 | GSC | 0.06 | INA | -0.15 | GAU | -0.23 |
| INA | 0.60 | INA | 0.24 | GAU | 0.11 | LCA | -0.12 | GOP | -0.13 |
| IGN | 0.70 | GOP | 0.24 | GOP | 0.36 | GOP | -0.11 | INA | -0.12 |
| | | | | INA | 0.42 | | | | |

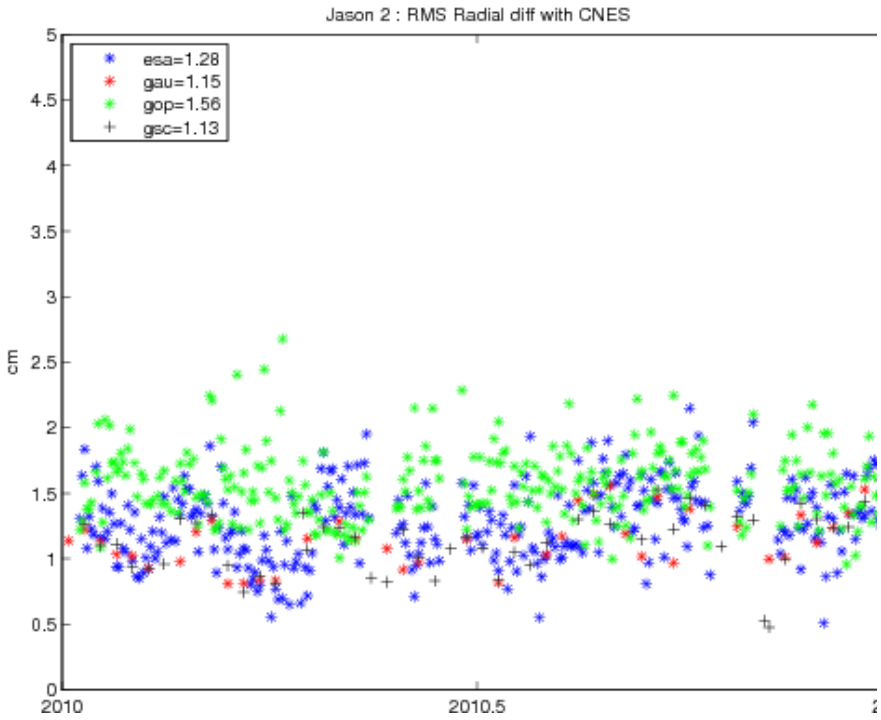
# Mean along-track diff wrt CNES (cm)

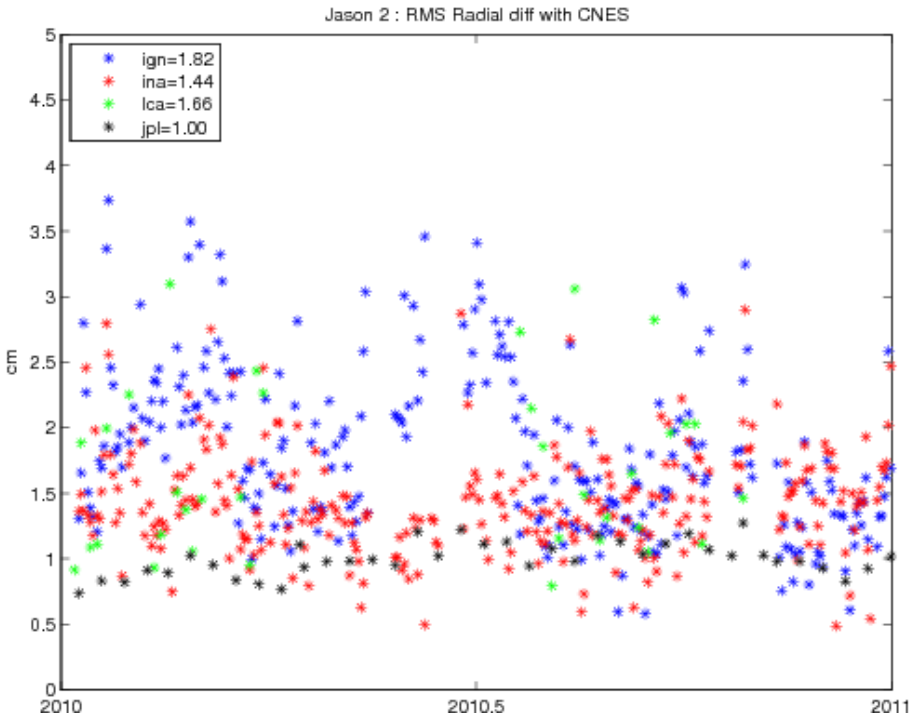
| C2 | | En | | J2 | | S4 | | S5 | |
|---|---|---|---|---|---|---|---|---|---|
| IGN | -0.89 | LCA | -0.94 | IGN | -1.49 | IGN | -1.23 | IGN | -1.68 |
| LCA | 0.04 | GSC | -0.82 | LCA | -0.45 | GOP | -0.42 | GOP | -1.49 |
| ESA | 0.52 | GAU | -0.78 | GOP | -0.44 | LCA | -0.33 | GSC | -0.60 |
| GSC | 0.53 | IGN | -0.74 | ESA | -0.24 | INA | -0.23 | GAU | -0.46 |
| GAU | 0.73 | ESA | -0.62 | INA | -0.17 | GAU | -0.23 | LCA | -0.27 |
| INA | 0.75 | INA | -0.39 | JPL | 0.00 | GSC | -0.14 | ESA | -0.24 |
| GOP | 0.87 | GOP | 0.43 | GSC | 0.18 | ESA | -0.08 | INA | -0.21 |
| | | | | GAU | 0.28 | | | | |

# Mean cross-track diff wrt CNES (cm)

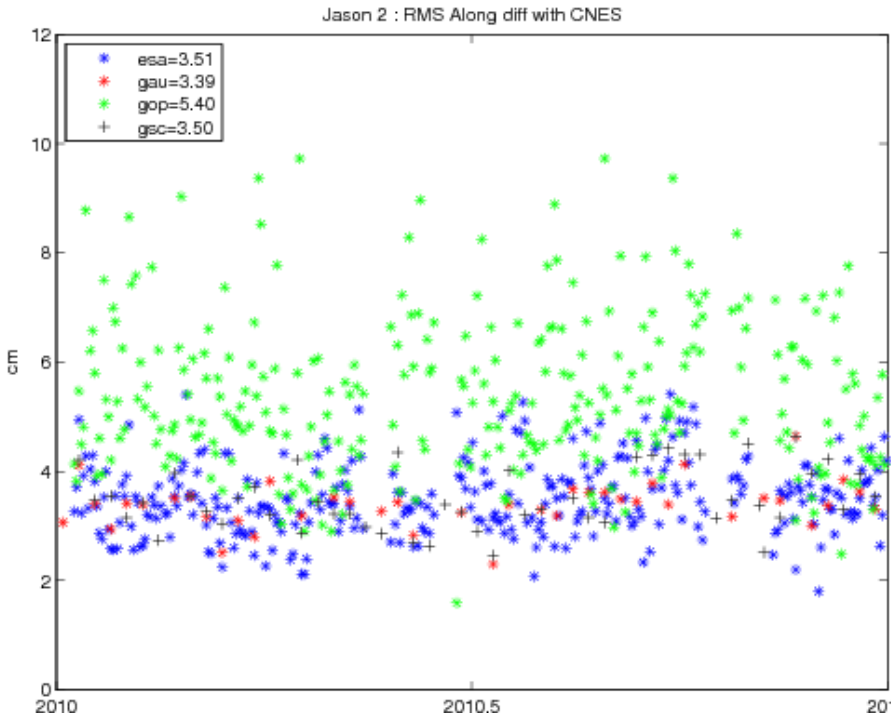
| C2 | | En | | J2 | | S4 | | S5 | |
|---|---|---|---|---|---|---|---|---|---|
| LCA | -0.18 | GAU | -0.90 | INA | -0.05 | GSC | -0.13 | GOP | -0.53 |
| GAU | -0.09 | GSC | -0.15 | GSC | -0.01 | GOP | 0.02 | GSC | -0.04 |
| GSC | -0.07 | INA | 0.01 | JPL | 0.03 | ESA | 0.07 | LCA | 0.13 |
| ESA | -0.05 | ESA | 0.05 | LCA | 0.04 | GAU | 0.08 | ESA | 0.21 |
| INA | 0.03 | LCA | 0.66 | ESA | 0.08 | LCA | 0.12 | GAU | 0.32 |
| IGN | 0.39 | GOP | 0.89 | GAU | 0.09 | INA | 0.24 | INA | 0.47 |
| GOP | 0.67 | ING | 0.94 | GOP | 0.29 | IGN | 0.72 | IGN | 1.07 |
| | | | | IGN | 1.45 | | | | |

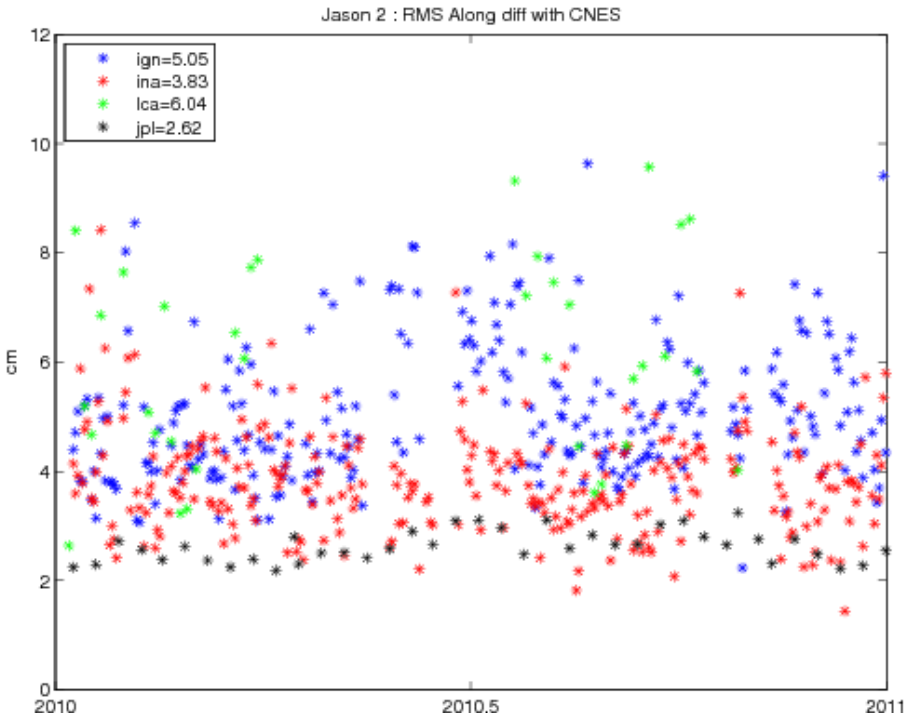
# Jason2 RMS Radial diff (*w. CNES*)



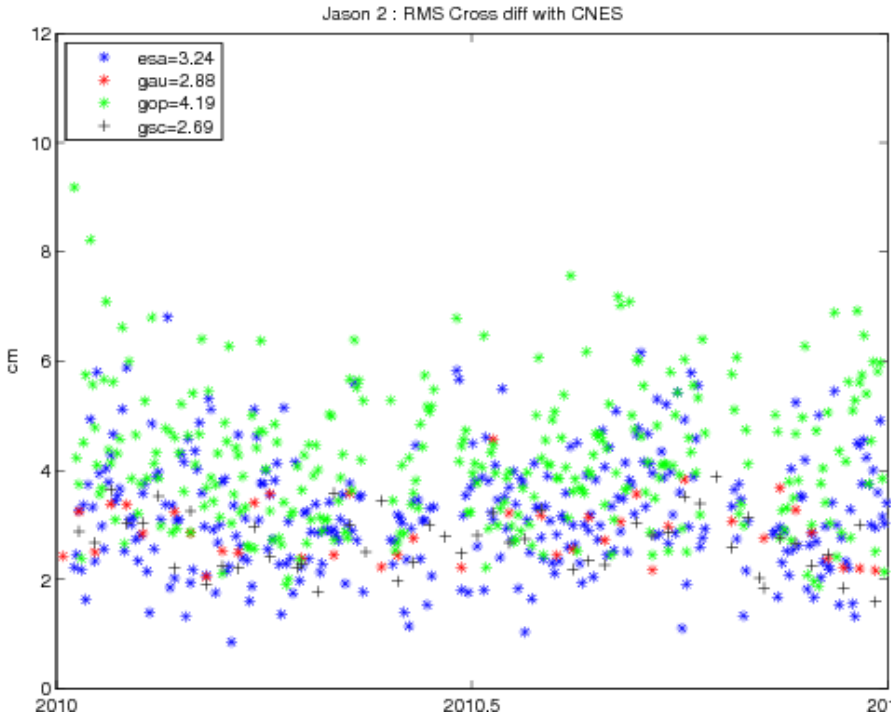



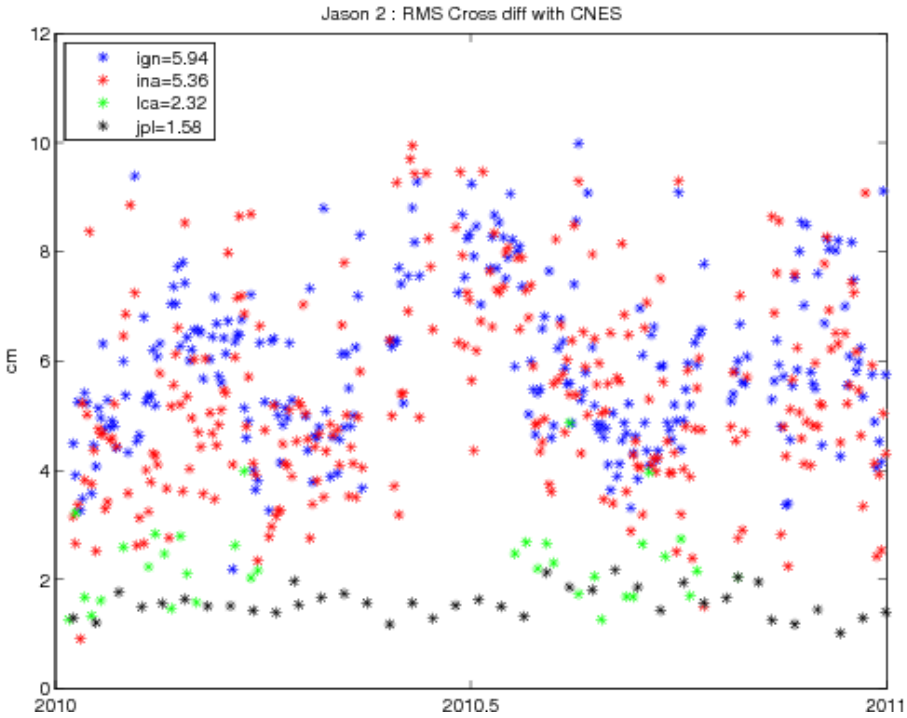
# Jason2 RMS Along-track diff (*w. CNES*)



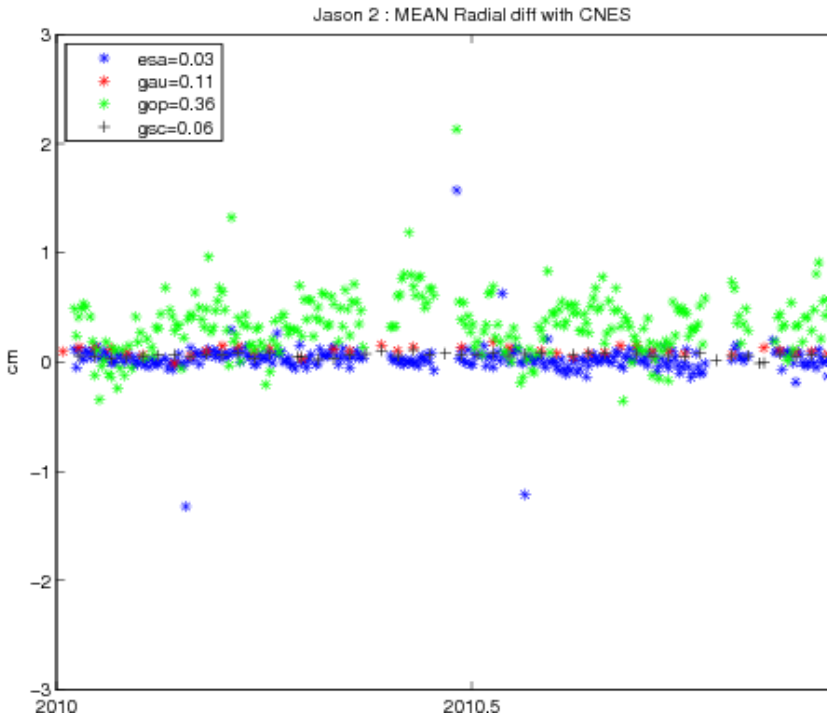



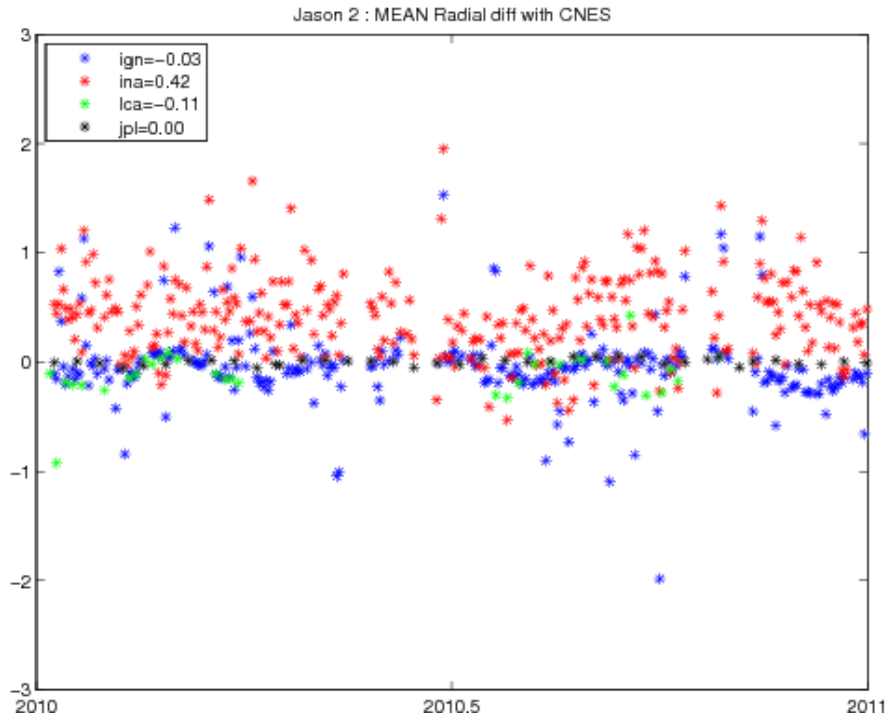
# Jason2 RMS Cross-track diff (*w. CNES*)



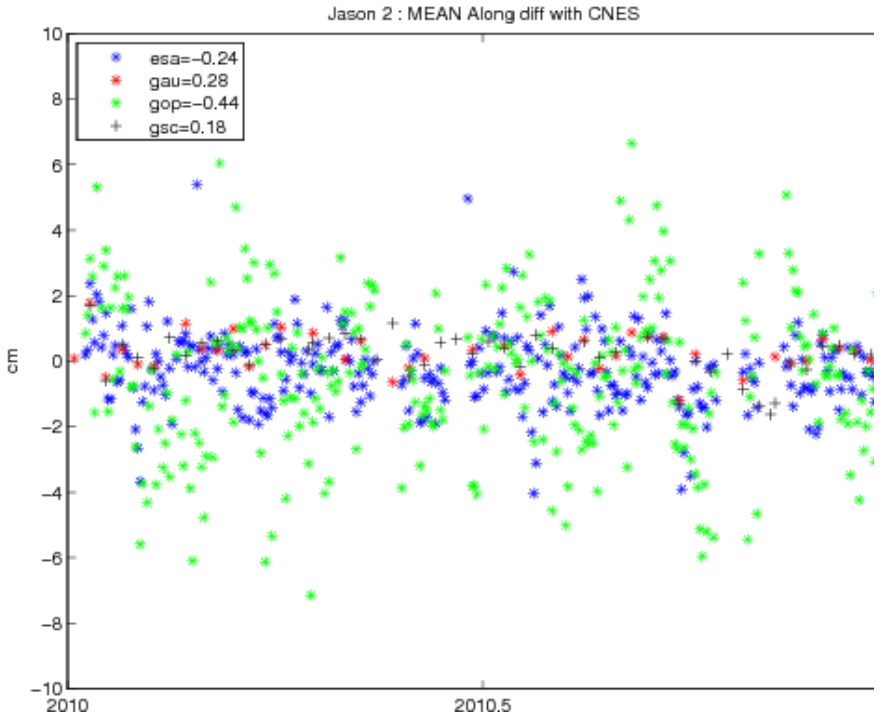



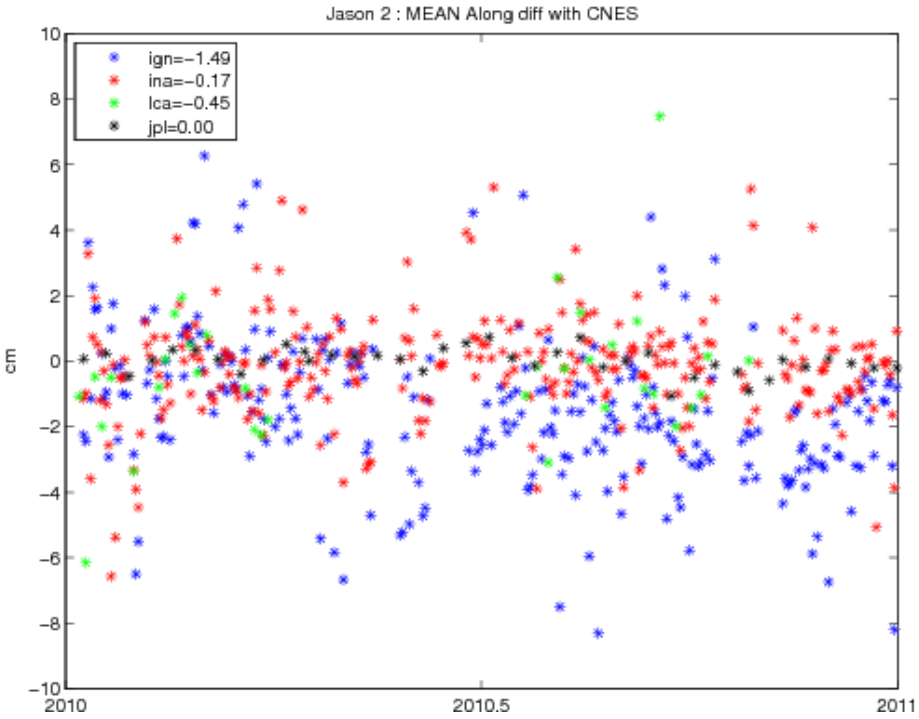
# Jason2 Mean Radial diff (*w. CNES*)



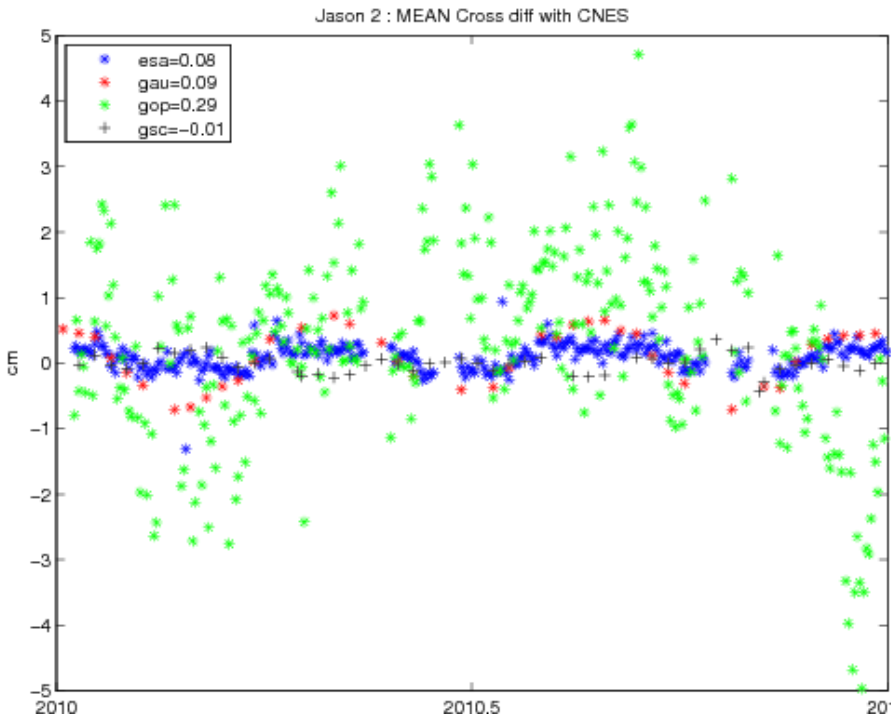



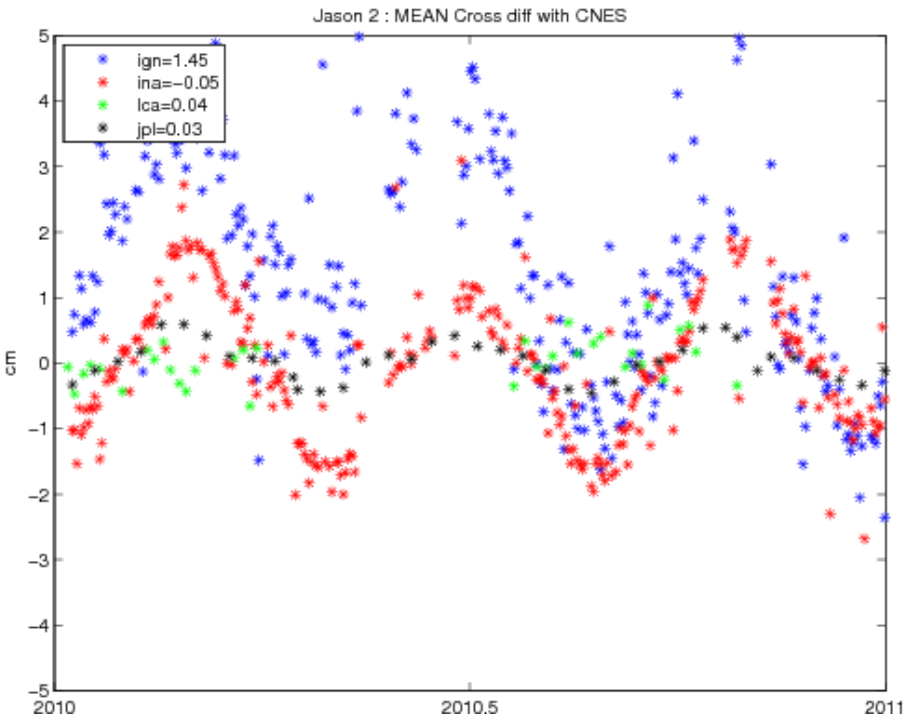
# Jason2 Mean Along-track diff (*w. CNES*)



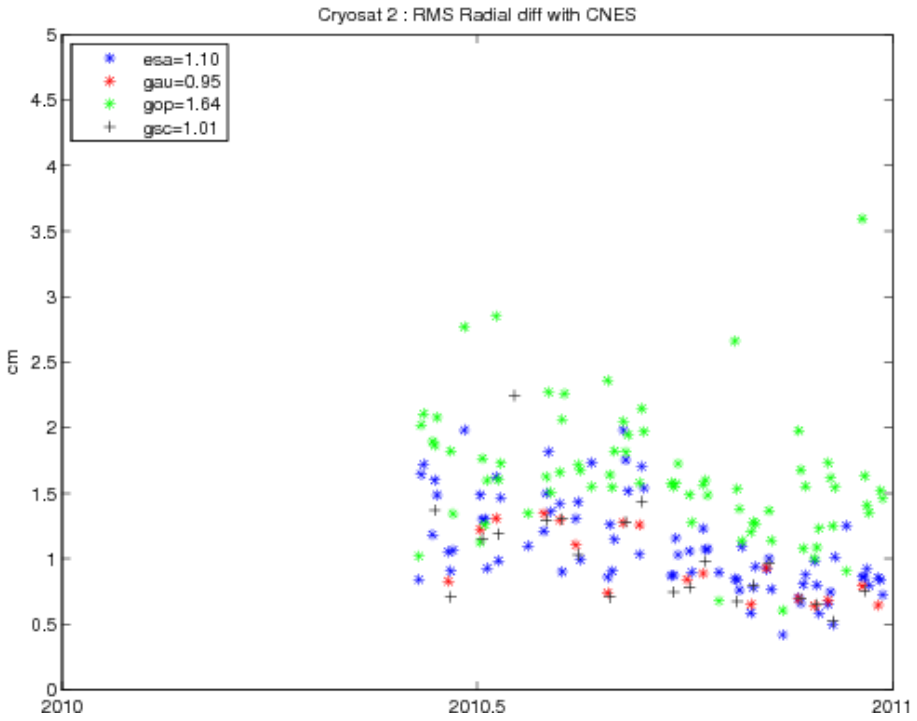



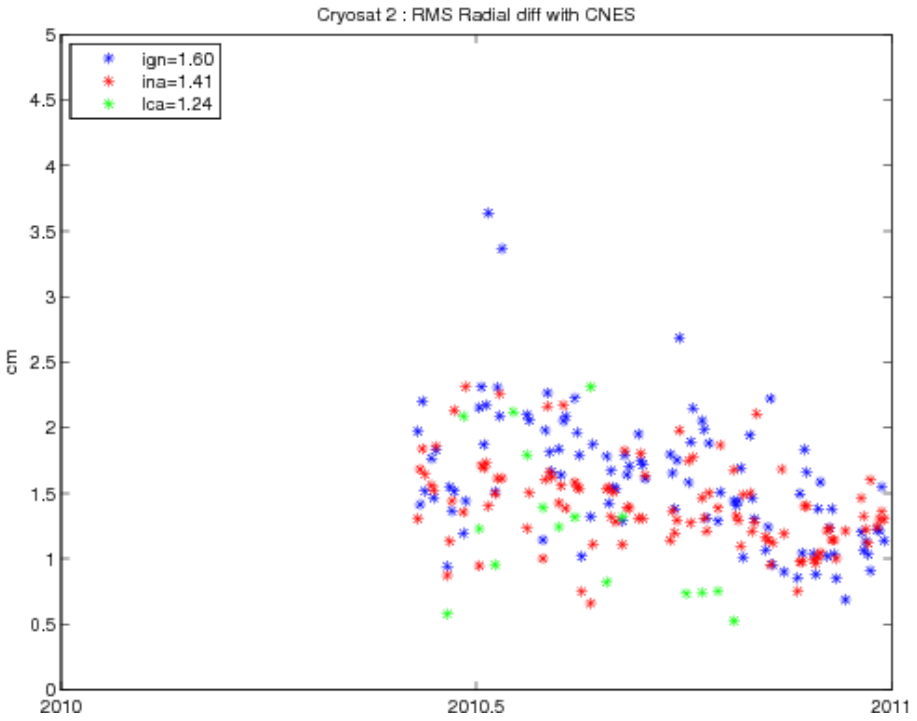
# Jason2 Mean Cross-track diff (*w. CNES*)



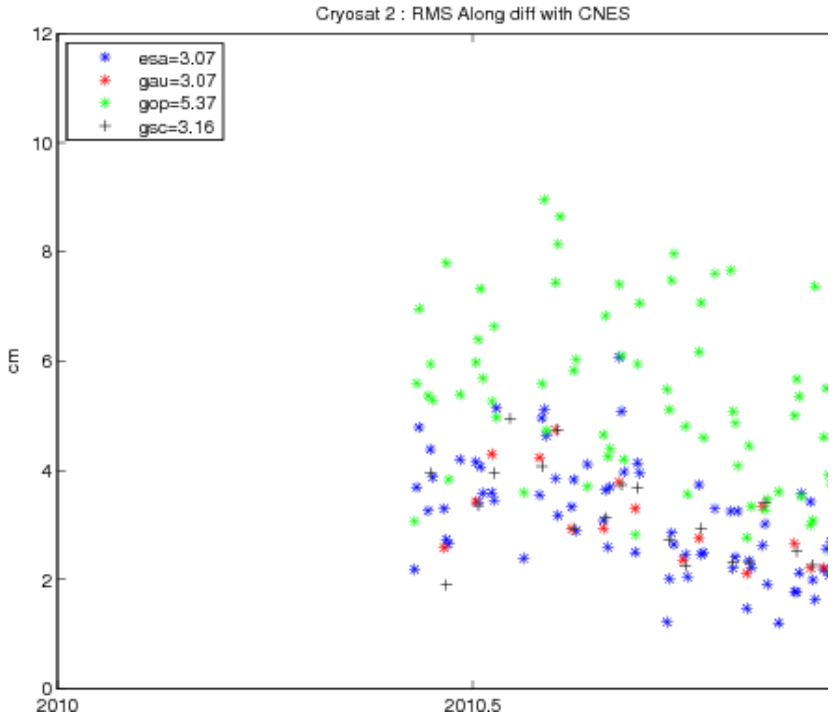



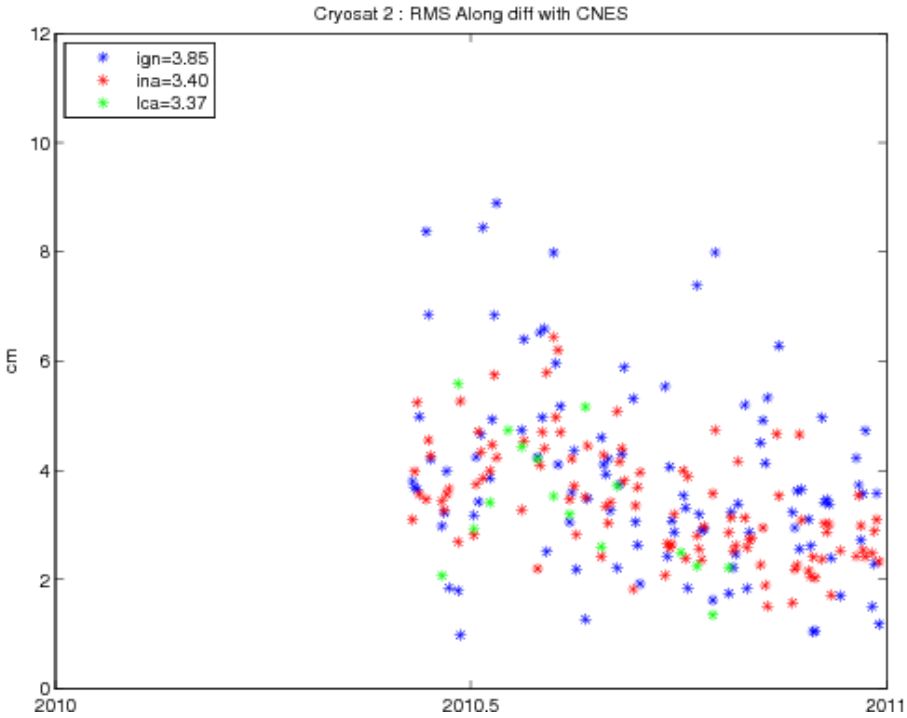
# Cryosat2 RMS Radial diff (*w. CNES*)



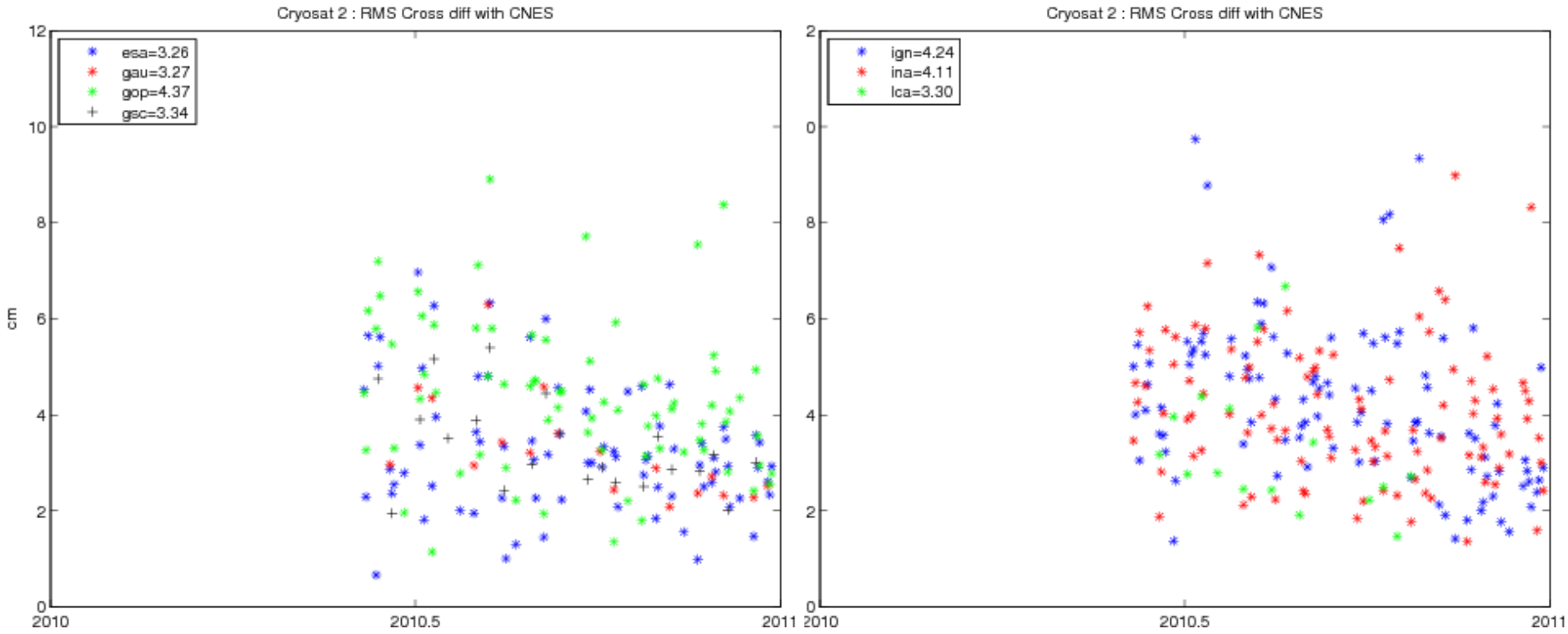



# Cryosat2 RMS Along-track diff (*w. CNES*)

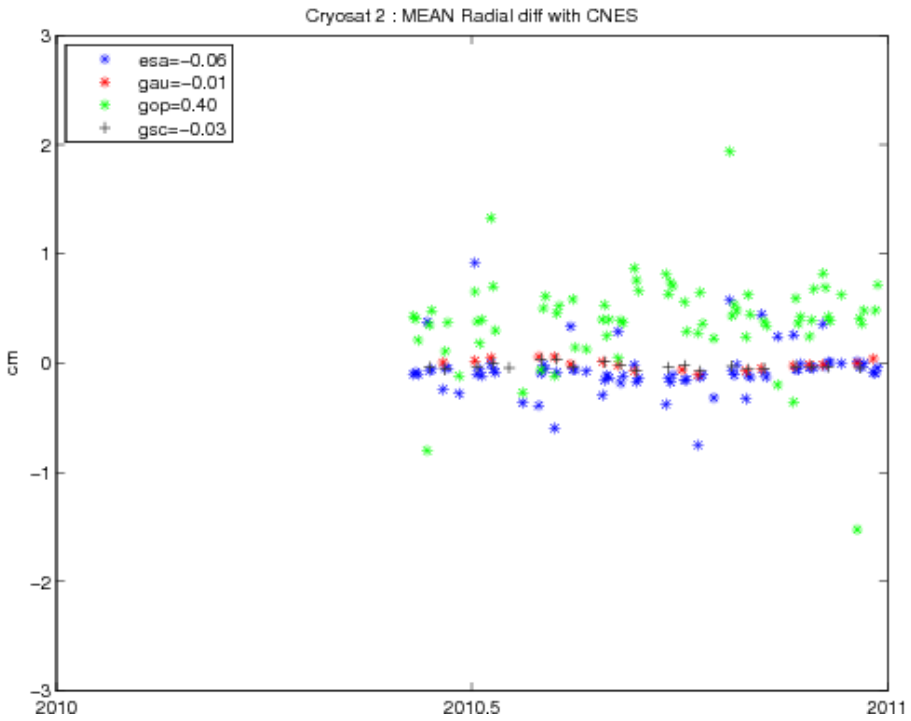


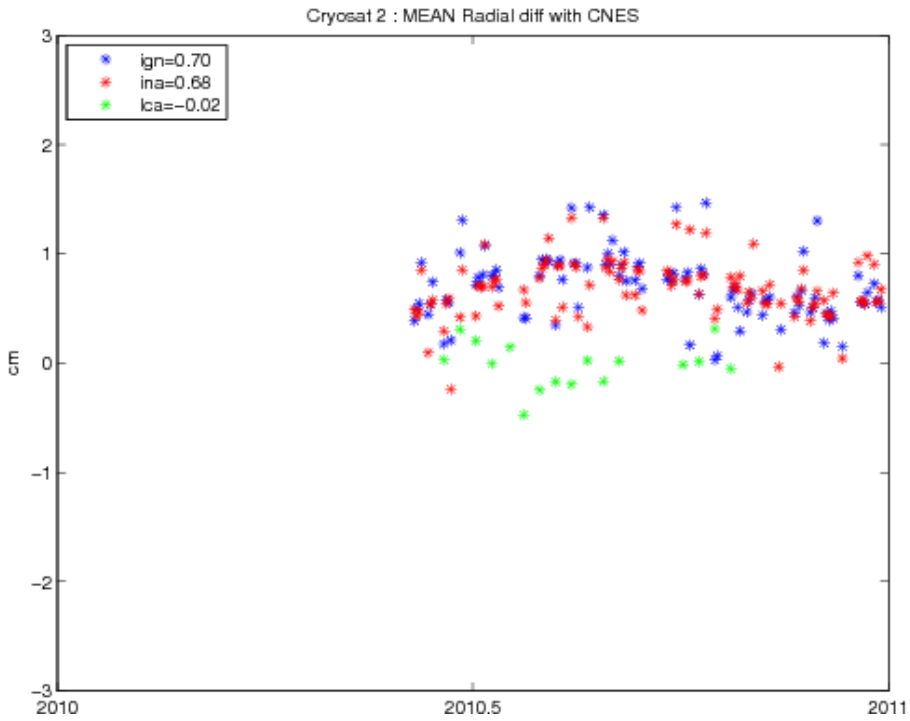



# Cryosat2 RMS Cross-track diff (*w. CNES*)

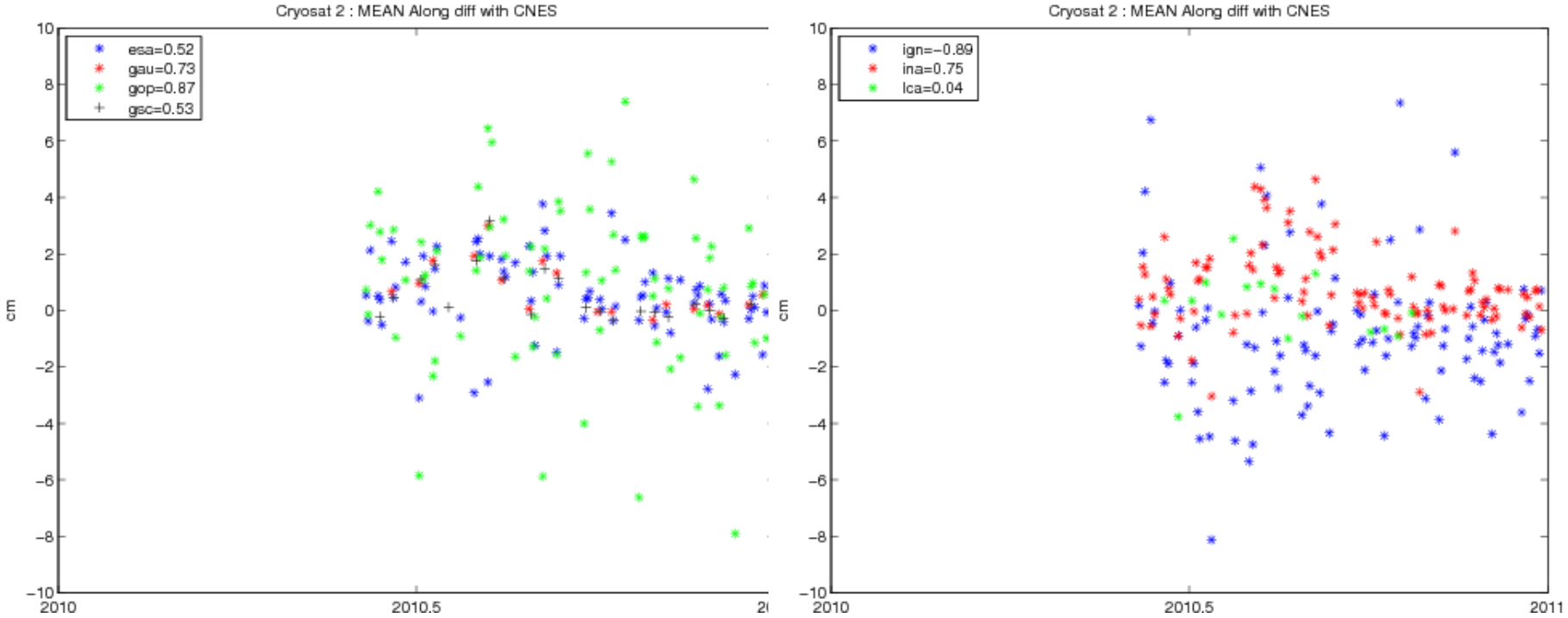


# Cryosat2 Mean Radial diff (*w. CNES*)

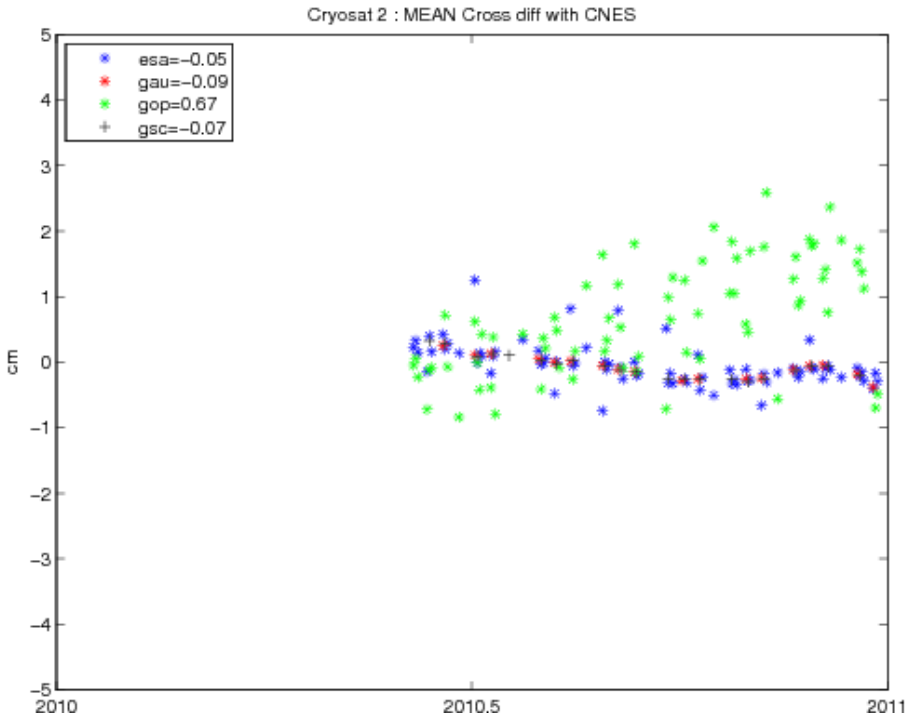


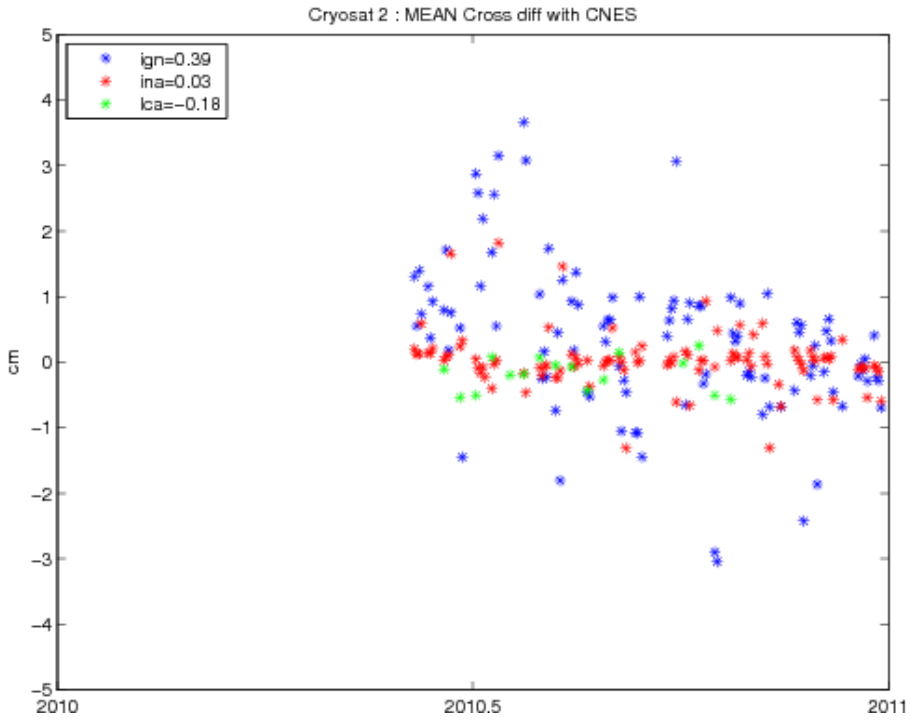



# Cryosat2 Mean Along-track diff (*w. CNES*)

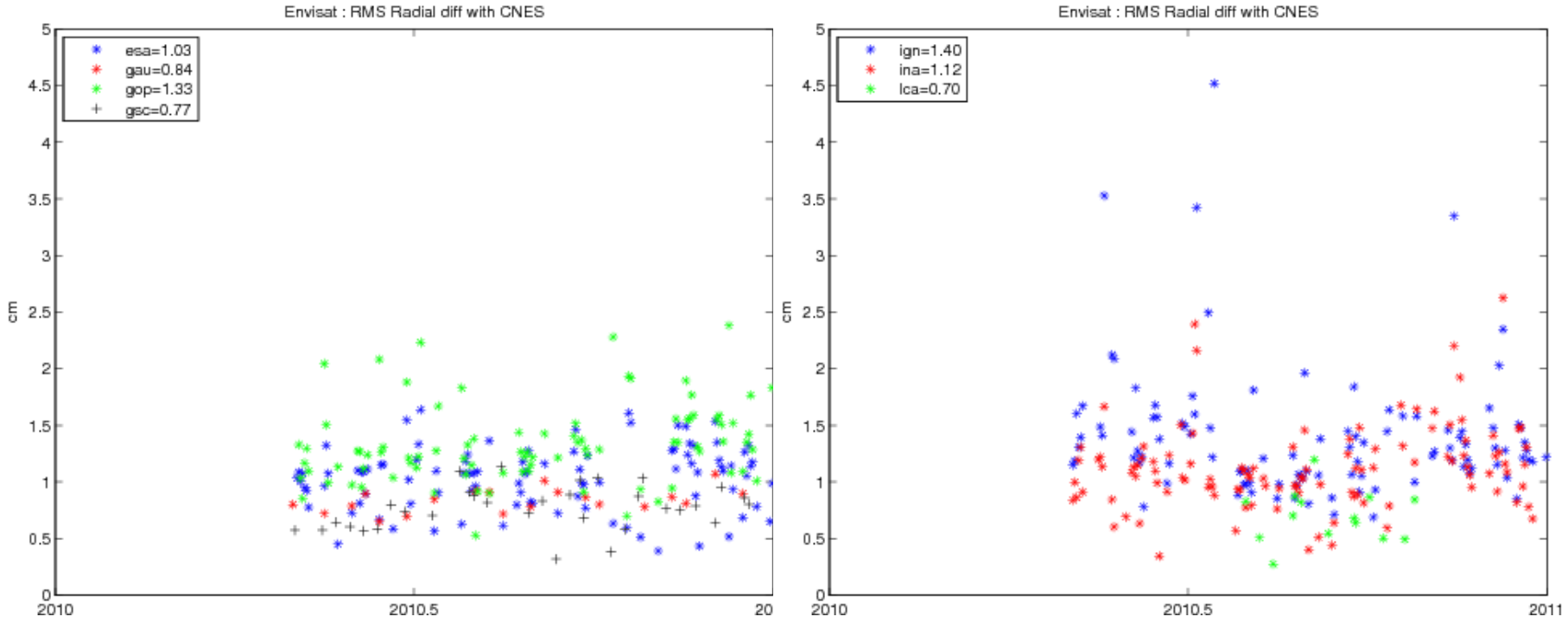


# Cryosat2 Cross-track Radial diff (*w. CNES*)

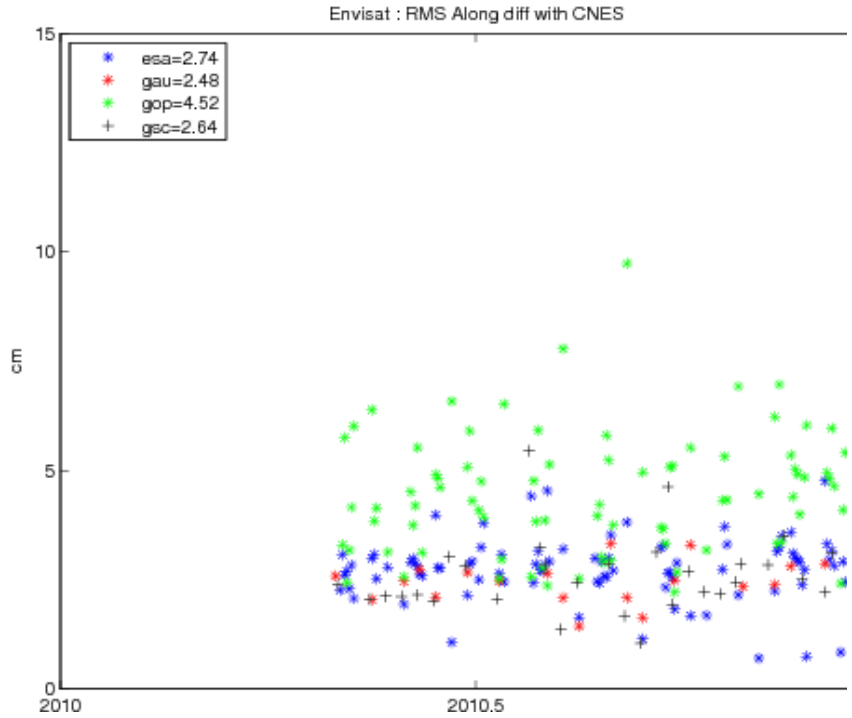


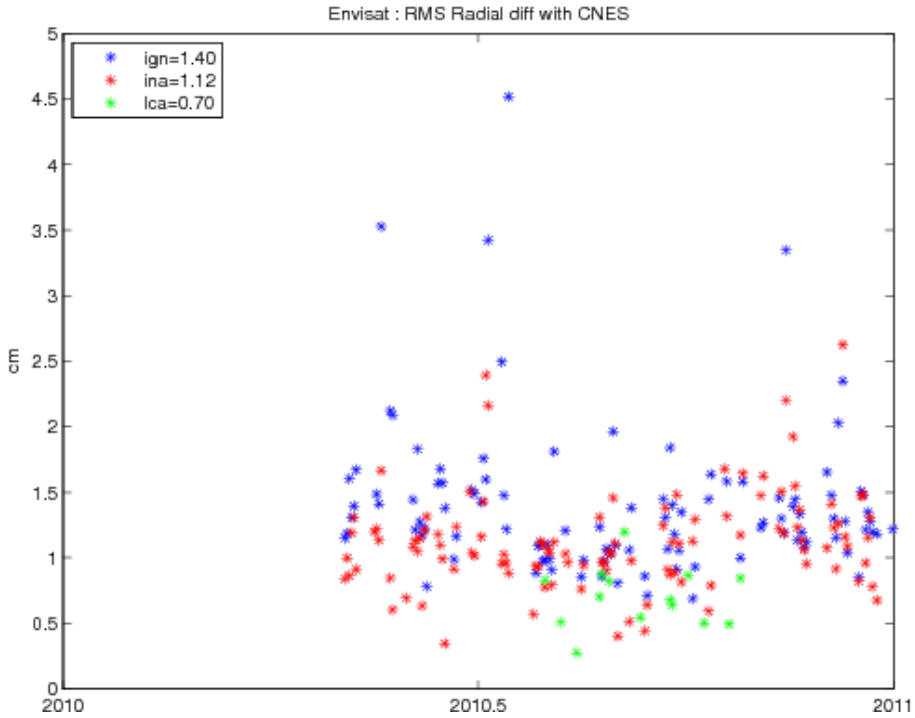



# Envisat RMS Radial diff (*w. CNES*)

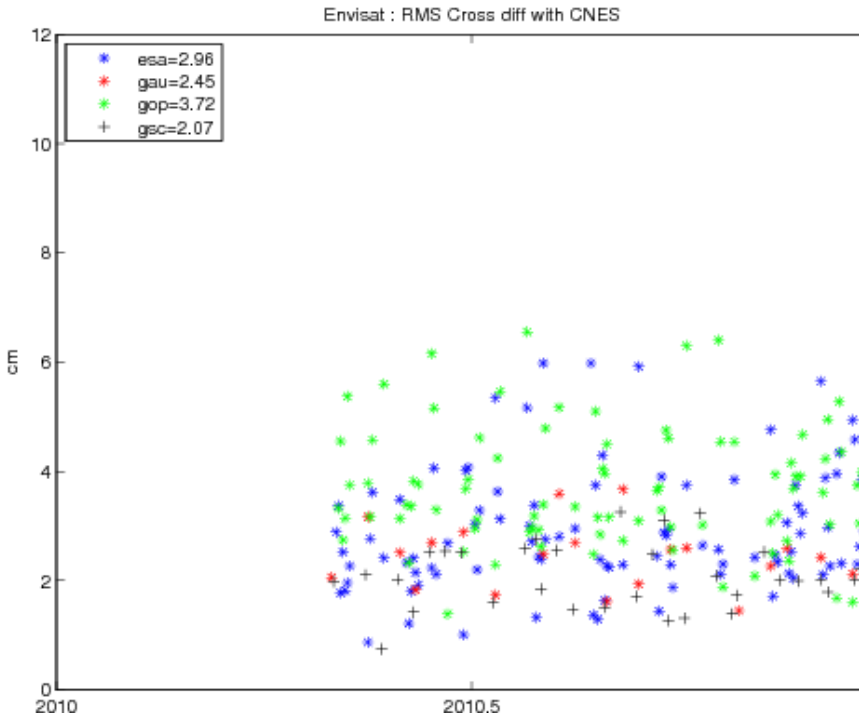


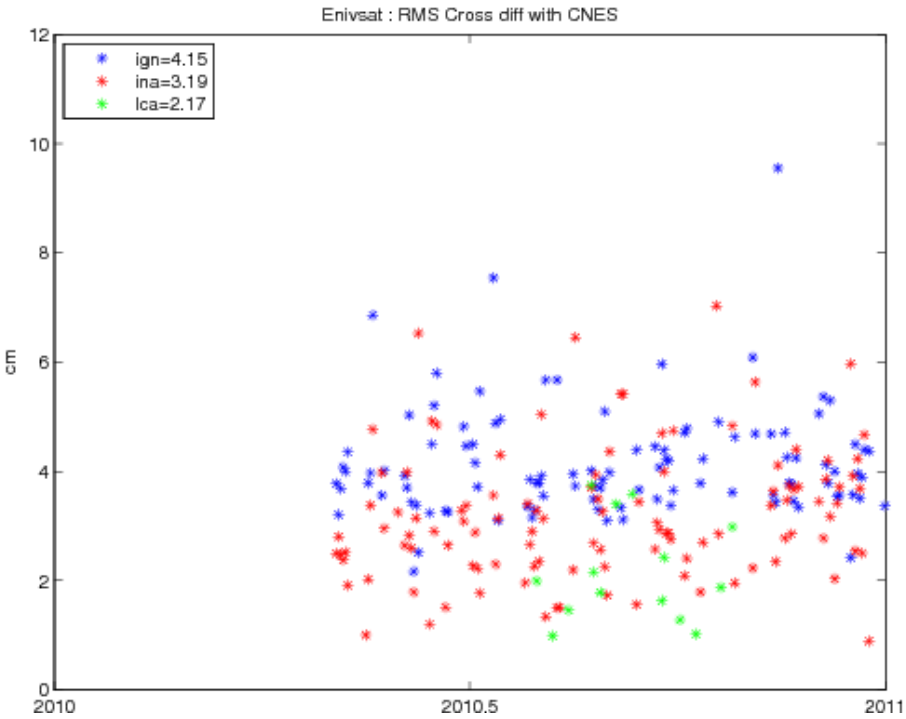
# Envisat RMS Along-track diff (*w. CNES*)



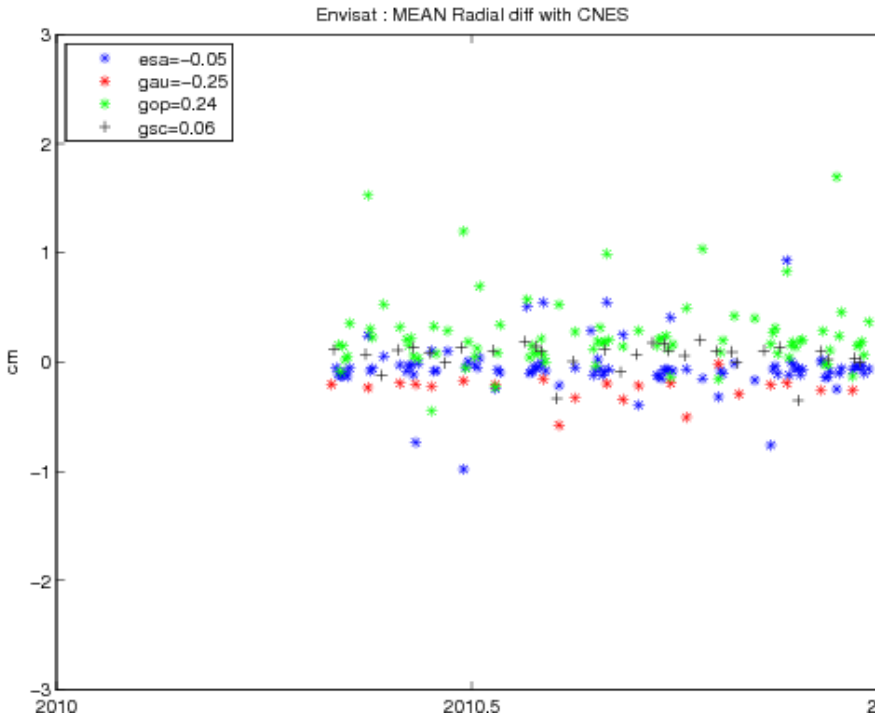



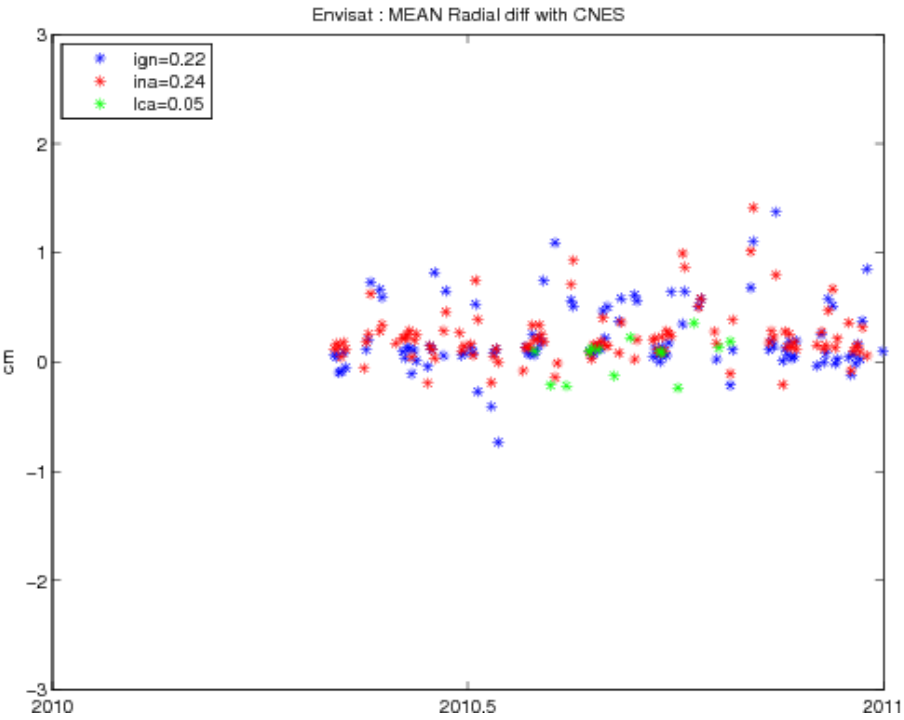
# Envisat RMS Cross-track diff (*w. CNES*)



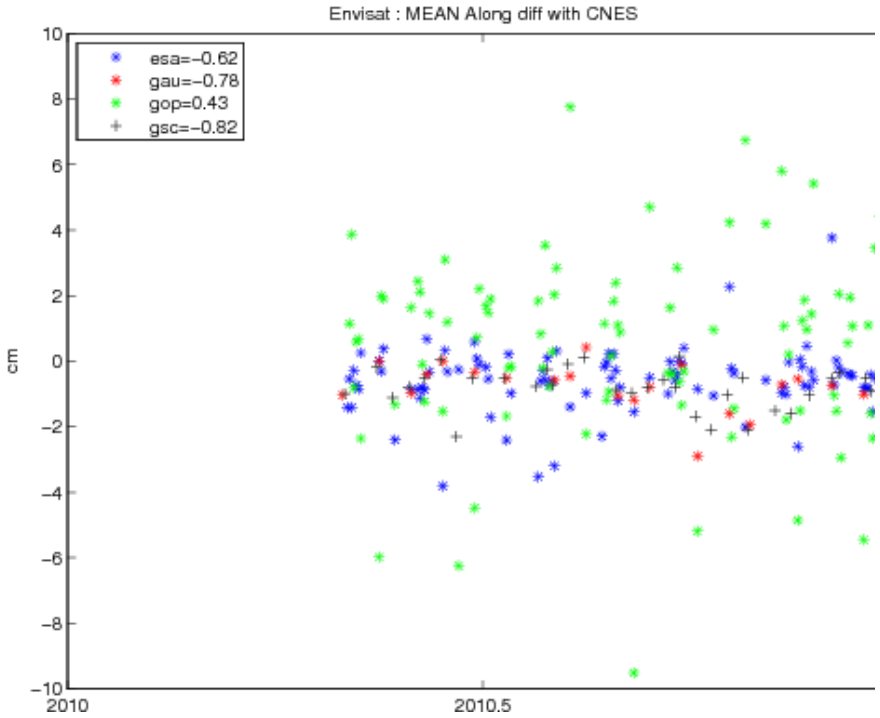



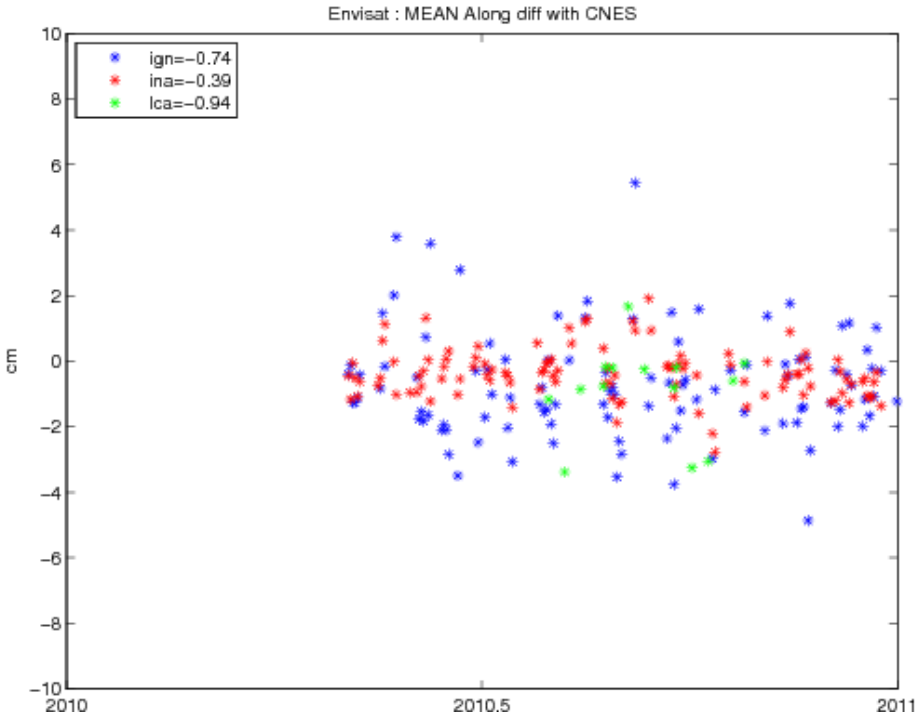
# Envisat Mean Radial diff (*w. CNES*)



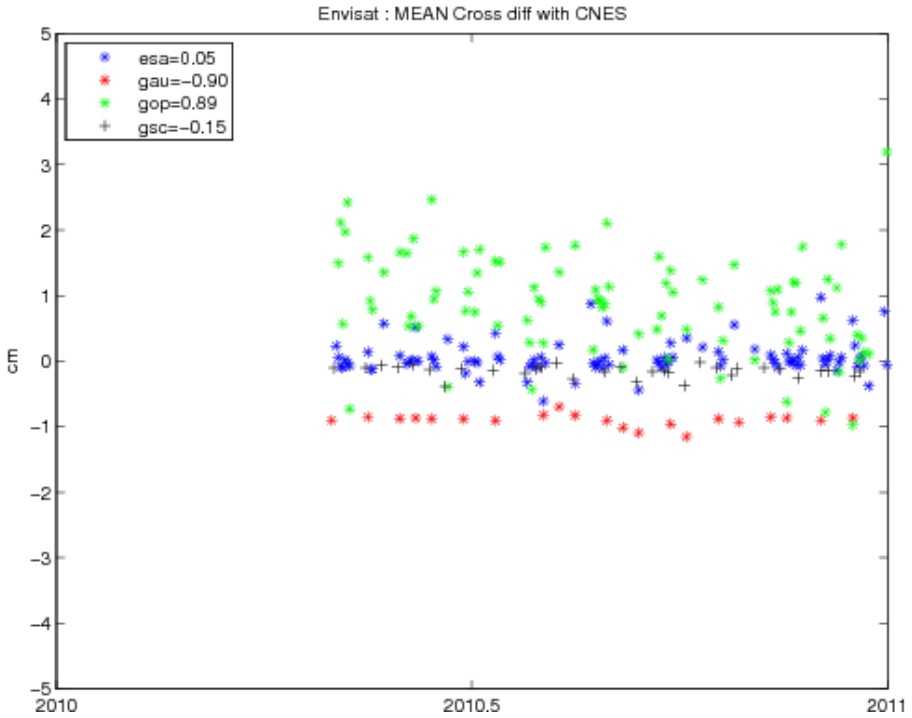



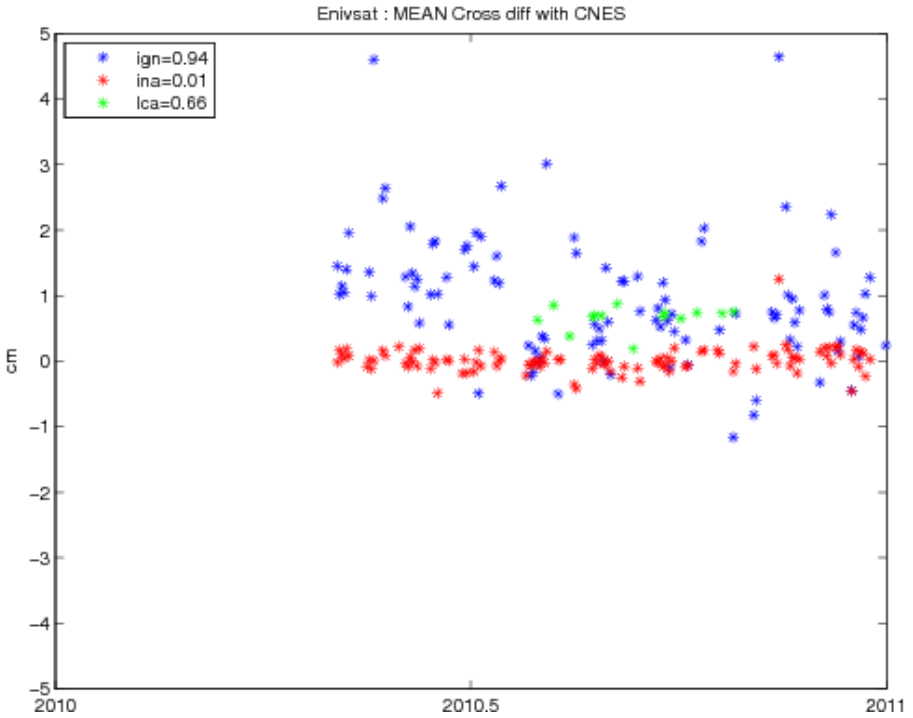
# Envisat Mean Along-track diff (*w. CNES*)



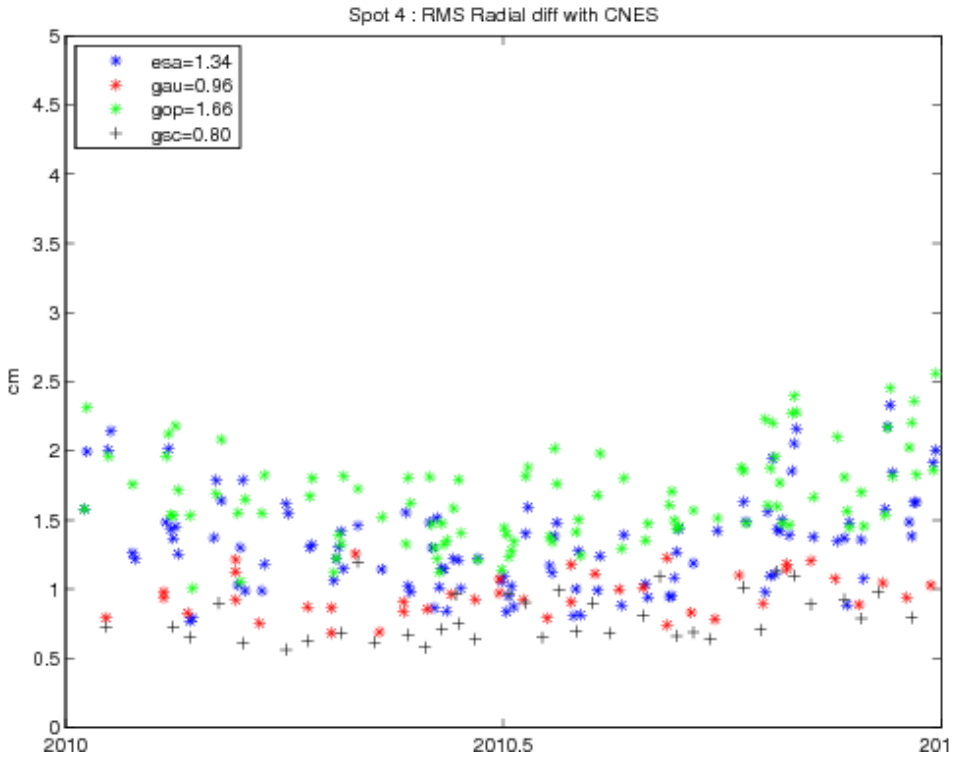



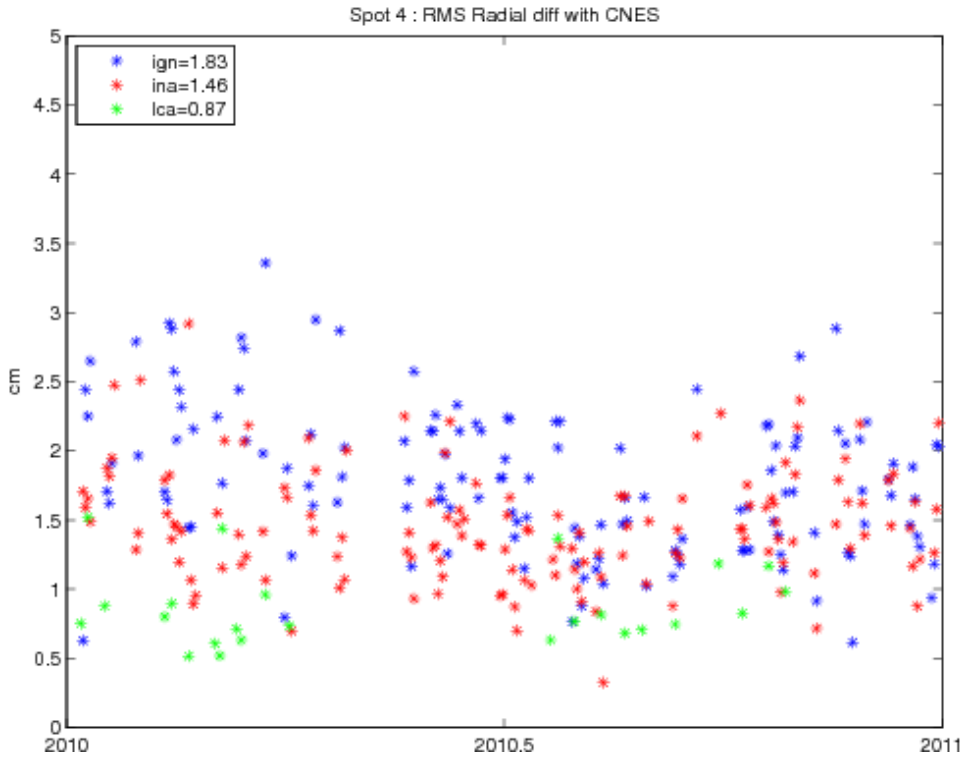
# Envisat Mean Cross-track diff (*w. CNES*)



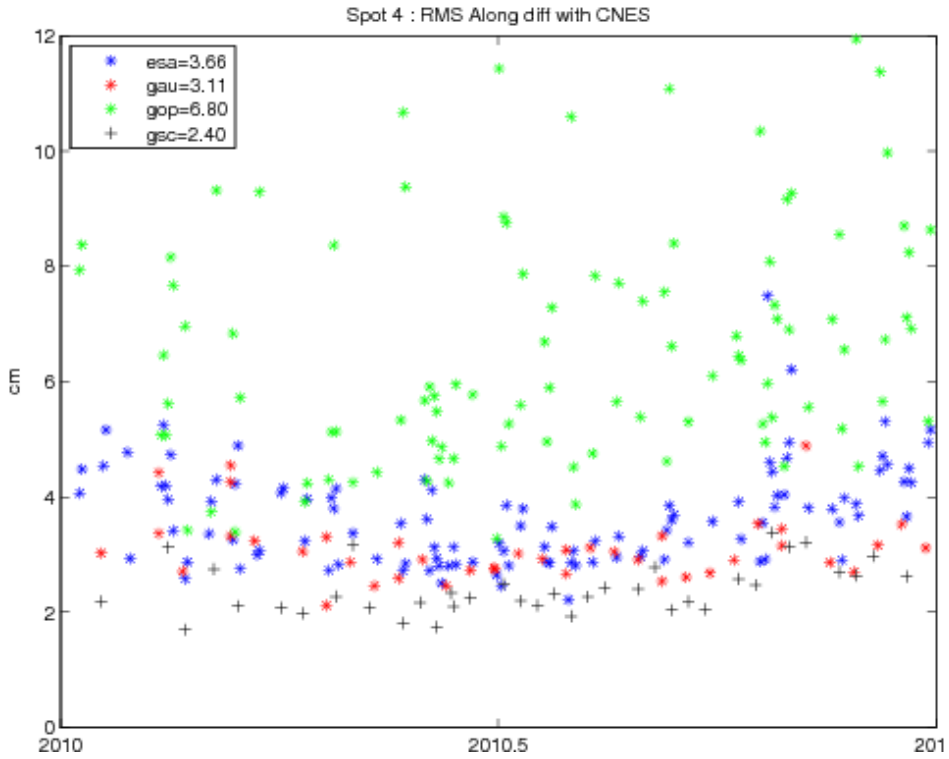



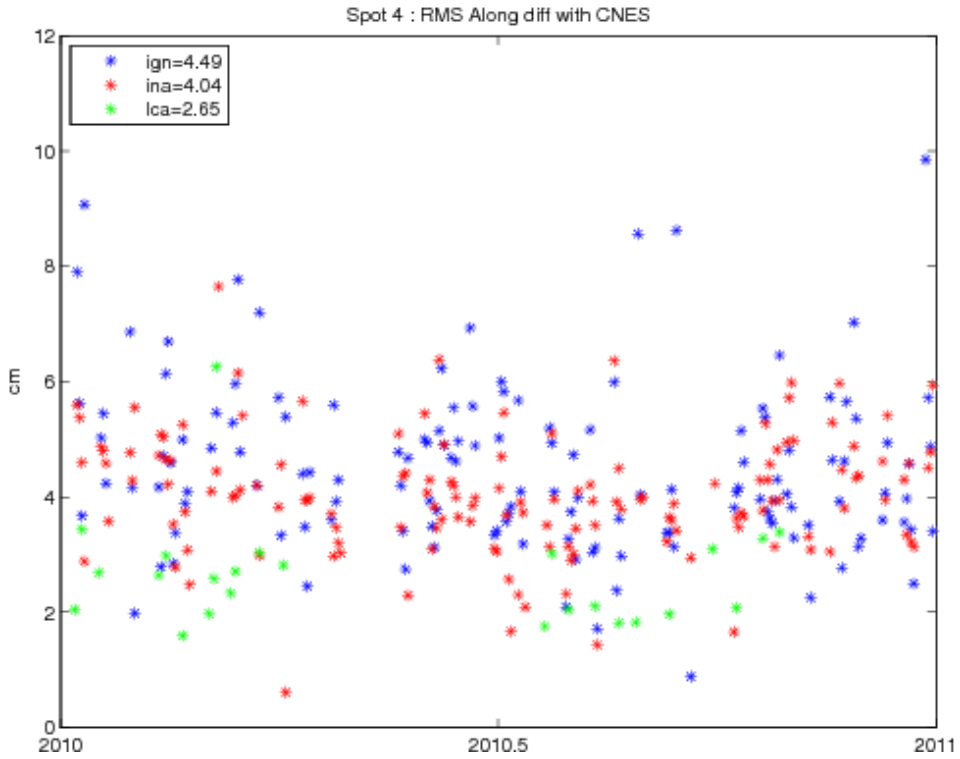
# SPOT4 RMS Radial diff (*w. CNES*)



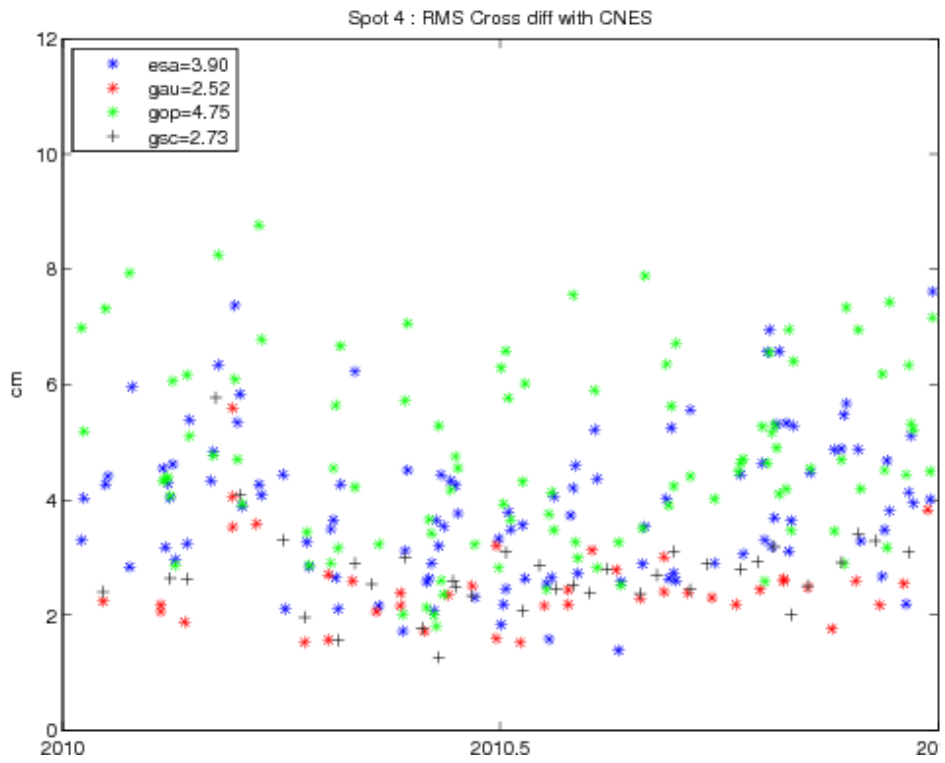



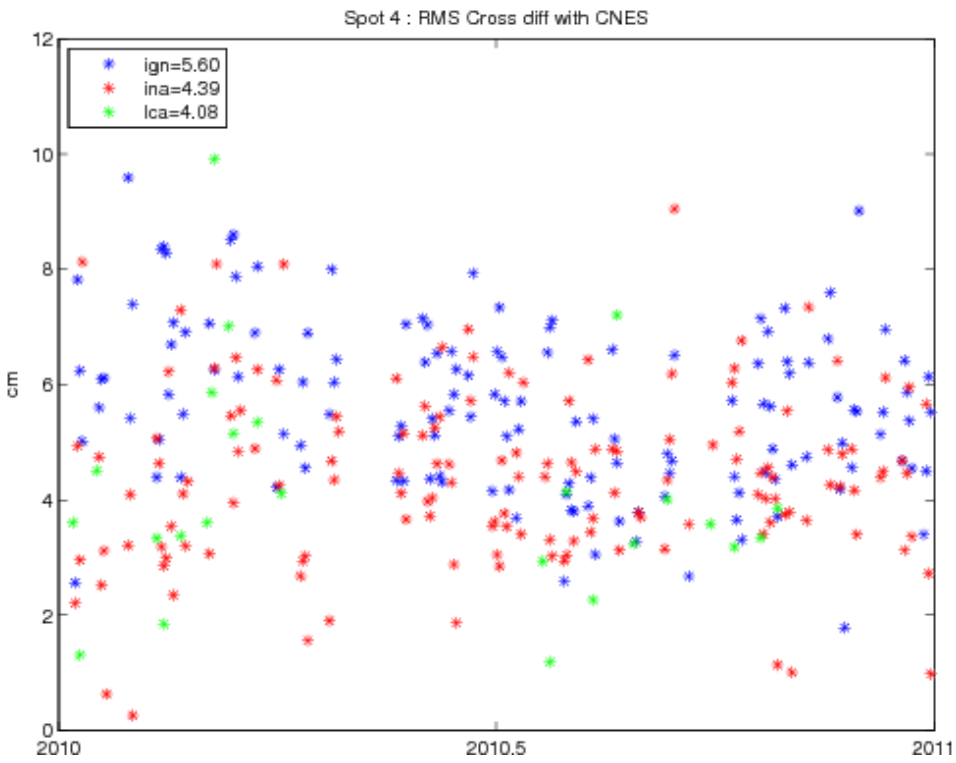
# SPOT4 RMS Along-track diff (*w. CNES*)



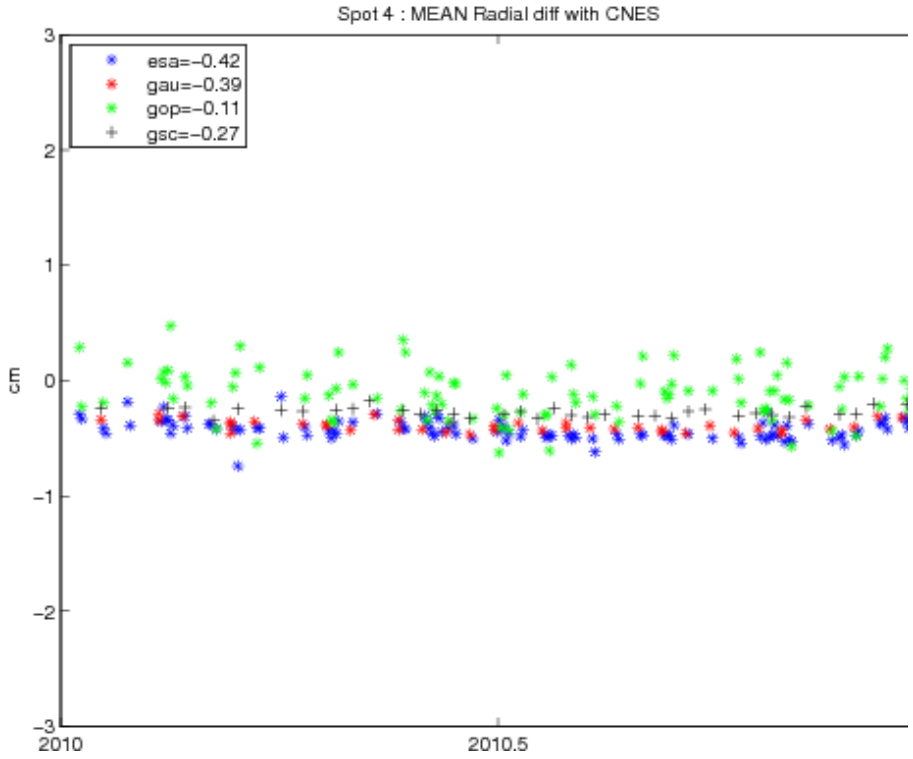



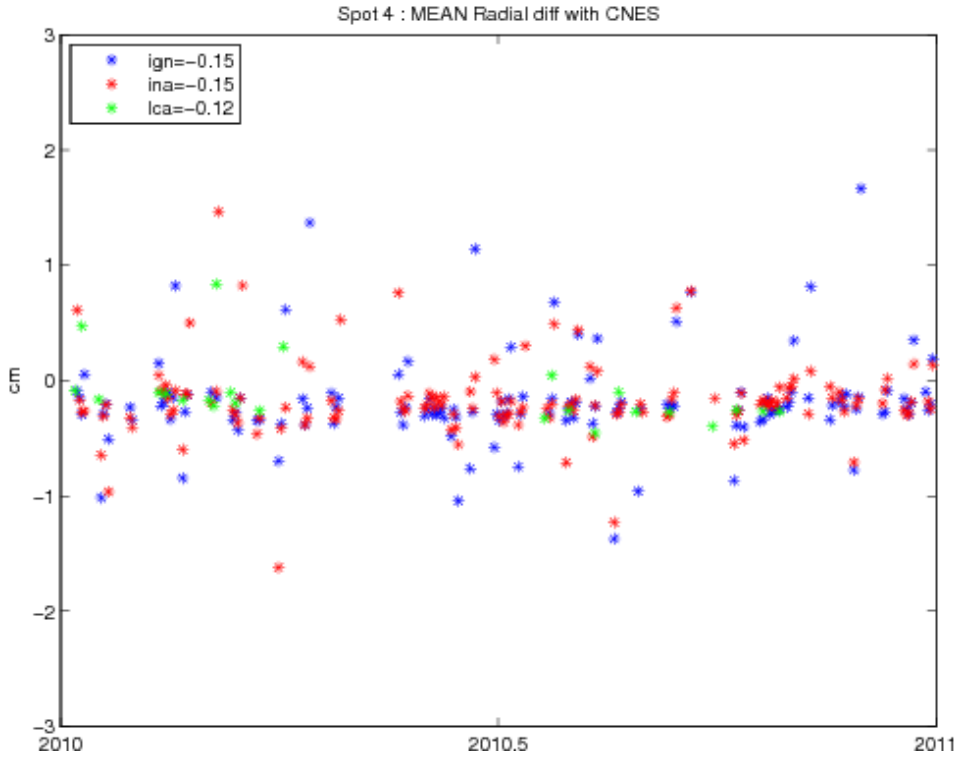
# SPOT4 RMS Cross-track diff (*w. CNES*)



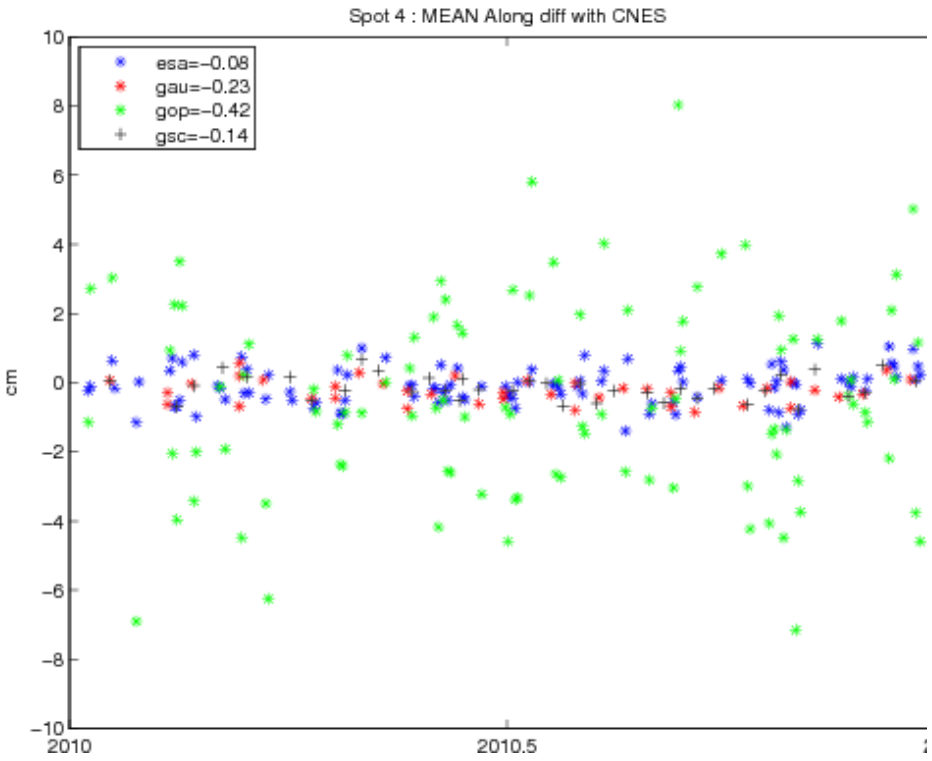



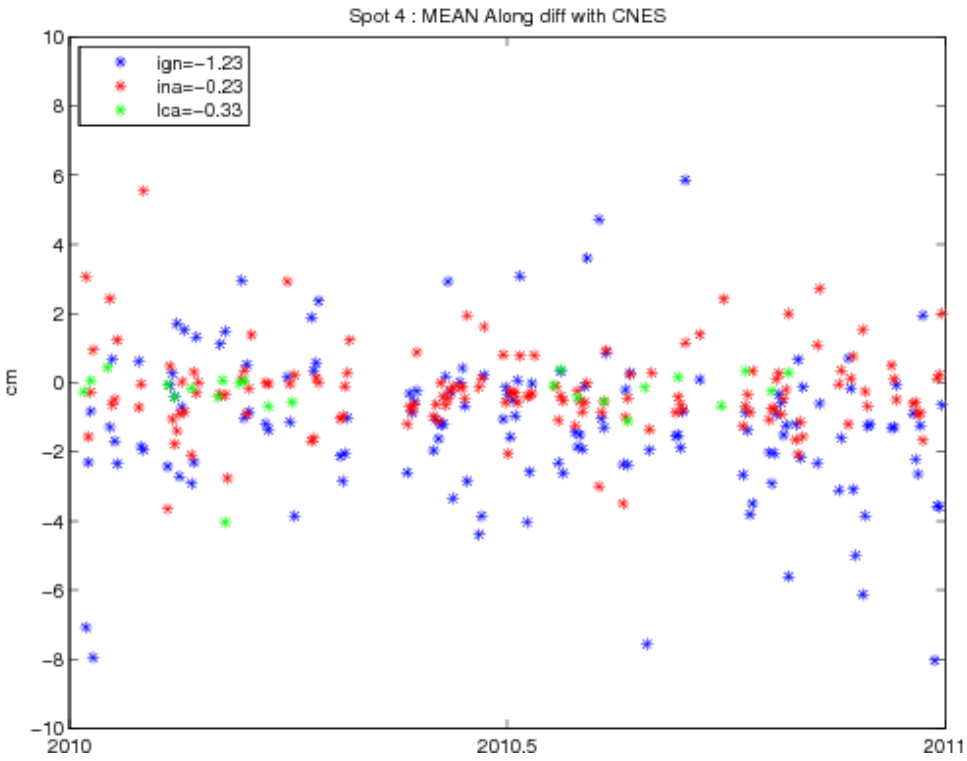
# SPOT4 Avg. Radial diff (*w. CNES*)



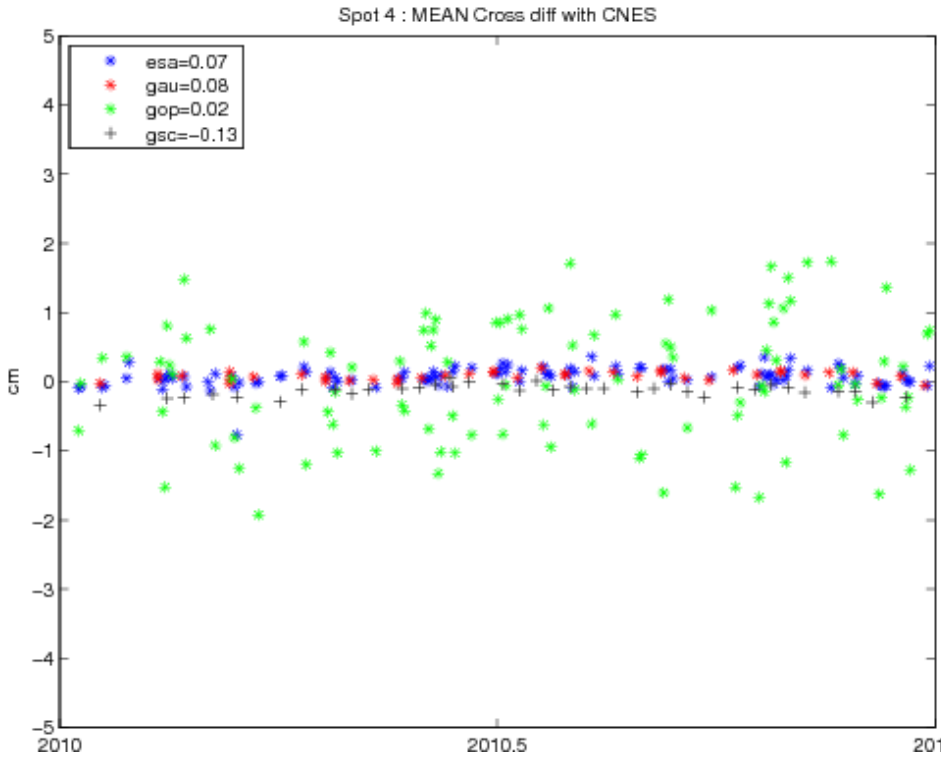



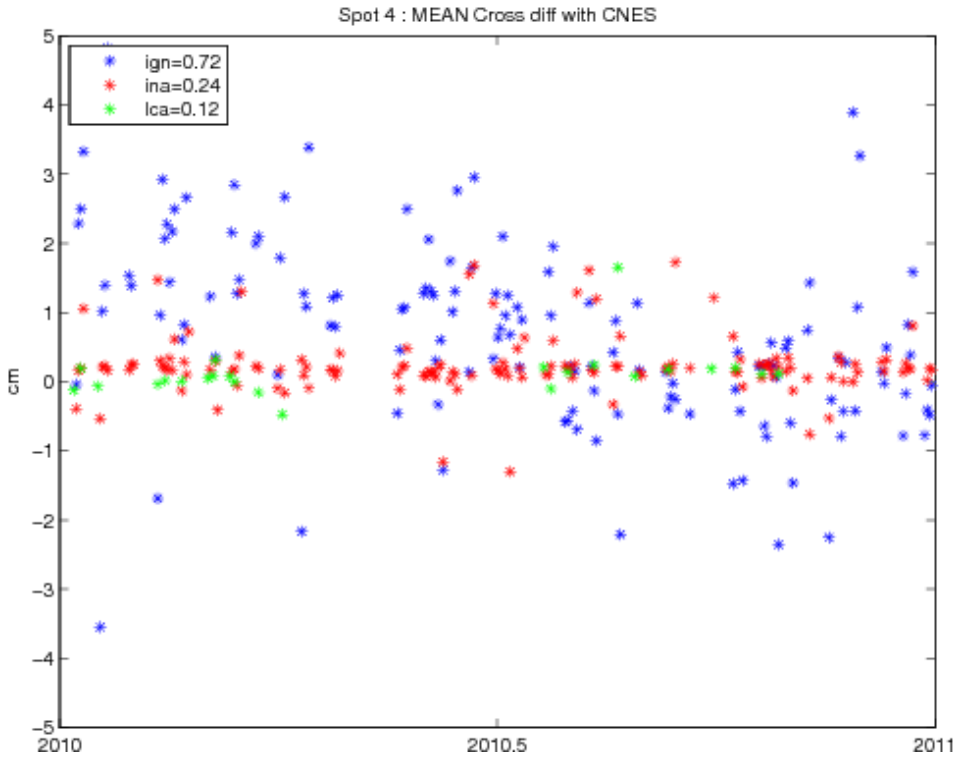
# SPOT4 Avg. Along-track diff (*w. CNES*)



# SPOT4 Avg. Cross-track diff (*w. CNES*)



# Summary

0. These were differences with an external reference: An alternative approach not tried – is to look at differences of Acs from an ensemble orbit… Possible – but it would mean doing a LSQ to all the AC orbits every week and then computing the differences. This would be a lot of work…

1. Radial orbit agreement, all satellites is 1-2 cm; Factor of 2X in radial orbit RMS difference magnitude bewteen ACs.

2. Along-track & Cross-track differences for IGN & INA on Jason2 show a strong beta-prime (~117 day) signature. Maybe the macromodel implementation in Gipsy should be examined?

3. There is somewhat of a scatter in the Cryosat2 results; Those ACs with larger differences, maybe could try the 7-plate (trapezoidal prism) macromodel.

4. Biases in Envisat modelling? GAU 1 cm cross-track? Examine Cr used?

5. Along-track Differences higher for GOP than other ACs. Is this result of stochastic method of Bernese? Would a priori dynamical model improve differences?

6. **We are happy to test new orbit series and perform other comparisons.**